SHANDONG UNIVERSITY

崇新学堂

2024 — 2025 学年第一学期

实验报告

课程名称：Introduction to EECS Lab

实验名称：DL9 - A Real Head-Turner

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Design Lab 9 - A Real Head-Turner

1. Introduction

The purpose of this experiment is to design and implement a simulated feedback system to control the robot's head towards the light source. Specific goals include:

Design and Build Circuit : Build a circuit based on analog feedback that allows the robot to adjust its head angle according to changes in ambient light intensity.

Demonstration of light source tracking : Using light sensors and servo motors, demonstrate how the robot uses analog signals and feedback control to achieve light source tracking.

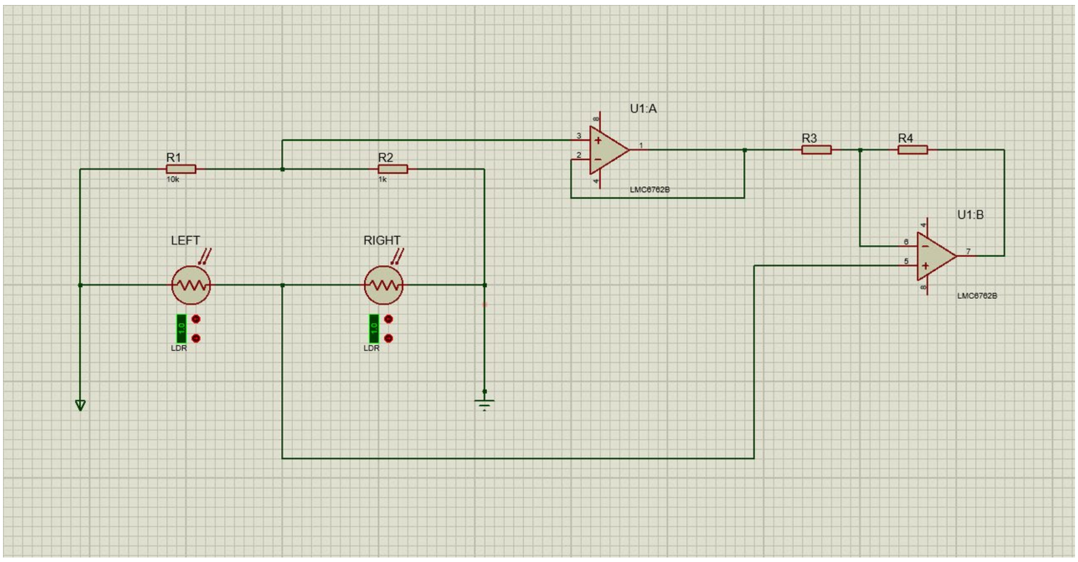
Optimize circuit performance : By adjusting circuit parameters, improve the tracking accuracy and response speed of the robot.

2. Experimental step

Step 1: Build the Circuit

The core of the circuit is a differential amplification circuit (specific operational amplifier models need to refer to the experimental guide), which compares the difference in light intensity between two photosensitive resistors. The difference in light intensity is converted into a voltage difference as an error signal.

This circuit has been built in Homework 3. In the following steps, we need to control this circuit to achieve its true function.



Circuit

Check Yourself 1

Verify that your circuit works by measuring the voltages across the motor, being sure that they behave appropriately as you change the light levels on the eyes. Demonstrate the correct behavior to a staff member, who will give you a black cable with which to connect the motor. (Remember that a positive voltage drop across the motor will turn the head to the left)

<u>We have used simulation in HW3 to test the stability of the circuit and found that its voltage conforms to normal conditions. According to the simulation diagram of HW3, the robot can achieve bidirectional steering.</u>

Step 2: Preliminary Functional Testing

This step validates the basic functionality of the constructed analog circuit. Firstly, cut off the power and disconnect the black cable connected to the motor. Then, when the lighting conditions change, measure the voltage at both ends of the motor to confirm that the voltage change matches the lighting change and is consistent with the expected behavior (positive voltage indicates head to left turn). Afterwards, connect the black cable and briefly turn on the power to observe if the robot's head is turning towards the light source. If the head smoothly turns towards the light source, it indicates that the circuit connection is correct; If the head impact stops or the operational amplifier overheats, it indicates a circuit connection error. This section emphasizes the preliminary verification and safety precautions of the circuit, as well as the error handling process.

Step 3: Connect the Middle Pin

Connects the middle pin (pin 2) of the potentiometer at the head and neck of the robot to the first analog input terminal of the robot connector.

Step 4: Plot the Neck Potentiometer Voltage

Use turnToLightAnalogBrain.py to plot the neck potentiometer voltage over time and determine the settling time of the system.

Step 5: Pick a Good Gain

Pick a good gain for your circuit so that you get as fast a response as possible (it shouldn’t have

significant oscillations, but a little overshoot is fine) over a range of distances from the light. Gather

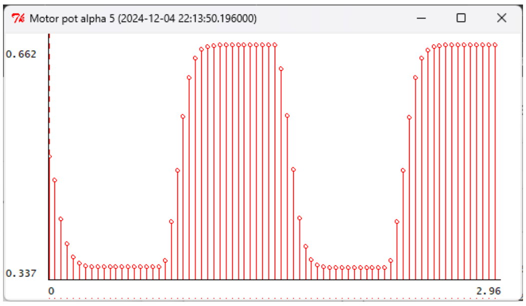
data with at least two different gains in your circuit and at least two distances. Save the graphs

and settle times for each.

Checkoff 1.

Illustrate your circuit and its performance at two different distances with the two gains you investigated. How does the settle time vary with gain and with distance? Keep your plots and measurements to discuss in your interview.

<u>Due to hardware damage, we are unable to complete this part of the content and can only roughly predict the experimental results through simulation. The specific simulation diagram is shown below.</u>



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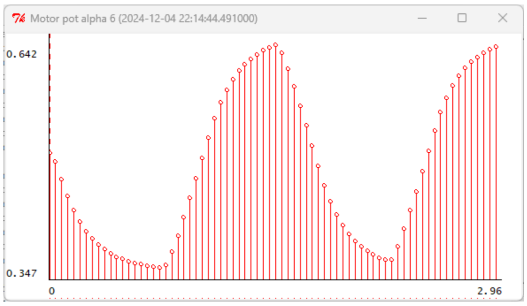

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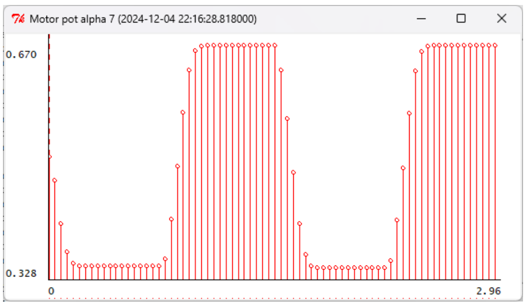

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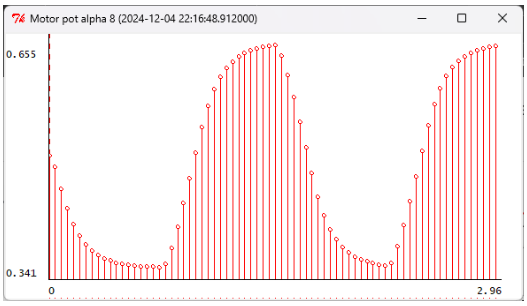

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Step 6: Plug in the Laser Connector

Turn off the power to the robot. Plug the laser connector (small black wire with round connector

near the yellow cable coming out of the robot) into the laser on your robot head.

Step 7: Make the Head Tracking as Accurate as Possible

Tune your circuit to make the head tracking as accurate as possible. Recall from Design Lab 7

that the photodetectors may not be matched perfectly. Consider how you could improve pointing

accuracy arising from mismatched photodetectors. Feel free to discuss your approach with the staff.

Checkoff 2.

Demonstrate the pointing accuracy of your head. Discuss what you did to your circuit to improve its accuracy. Describe the fundamental limitations to its accuracy.

The resolution and response speed of the light sensor determine the minimum change in light intensity that the system can perceive. In low-light environments, the sensor may not accurately capture the position of the light source, resulting in a decrease in accuracy.

The accuracy and resolution of the motor are limited, and there may still be slight deviations in the final position of the robot's head. We can weaken some of the effects by series resistance, but this will make the robot dull.

3. Summary

The goal of this experiment is to design and implement a robot head pointing system based on simulated feedback control, which can automatically face the light source. However, due to the failure of the laboratory car, many experimental steps were not completed. Nevertheless, we still partially implemented the experimental content through theoretical analysis and circuit design, and further understood the experimental goals.

Circuit Design : Although we were unable to complete the actual robot head control, we still completed the circuit design part. We designed an analog feedback control circuit (completed in HW3), using photoresistors and operational amplifiers to process the light intensity signal, which is actually the previous content.

Simulation Test : Due to the inability to use the car, we were unable to perform actual robot motion control. However, we verified the rationality of the feedback control principle and circuit composition used in the design through theoretical derivation and circuit simulation. By using the CMax simulation environment and simple circuit testing, we preliminarily verified the effectiveness of the circuit in the simulation environment.